CONTRACT SERIAL NO.
23440-9-9142-01-SZ

CONTRACTOR:
UNIVERSITY OF WESTERN ONTARIO

Final Report on:

D.S.S. Contract No.23440-9-9142/01-SZ

PHASE II

Feasibility Studies for Coal Dust Control Measures for the Breaker, C1, C1/C2 Transfer Houses at the Quintette Mine

Scientific Authority
Dr. K.J. Mintz
CANMET

Project Engineer
Martin L. Wick

Principal Investigator
Professor I. I. Inculet, P.Eng.

25 May 1991

MICROMEDIA
25 pp

92-01276/

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CARACTÉRISATION ET CONTRÔLE DES HASARDS ASSOCIÉS

AVEC LA POUSSIÈRE DE CHARBON DE QUINTETTE B.C.

SOMMAIRE POUR LA DIRECTION

LE CENTRE DE RECHERCHE EN ÉLECTROSTATIQUE APPLIQUÉE DE L'UNIVERSITÉ WESTERN ONTARIO a reçu un contrat la-dessus de D.S.S.
[no. 2344-9-9142/01-SZ], Phase II Pour déterminer la faisabilité de contrôler les émanations des poussières de charbon à Quintette Mine - B.C.

Le coordinateur scientifique pour le contrat est Dr. K.J. Mintz. AERC a fait des essais préliminaires, le 13 Septembre, 1990 suivis par des essais faits le 4 Mars, 1991 dans le C3 Tranfert Bâtiment.

Les Résultats indiquent:

1. L'injection d'ions monopolaires donne une réduction importante des poussières de charbon.

2. L'appareil experimental installé à Quintette a décru l'émanation de poussière environ de 30%

Recommandations:

1. AERC recommande une nouvelle série d'essais l'hiver prochain ou plus tôt, si possible. On devra s'assurer de les faire dans une des periodes critique a tres hautes concentrations de poussière de charbon.

2. Ajouter 4 injecteurs d'ions dans le même endroit.

3. Faire des essais supplémentaires pour confirmer les résultats de 4 Mars, 1991 avec des milipore filtres au lieu de la sonde optique et mesurer en même temps l'amélioration obtenue au moyen des injecteurs additionnels.

Executive Summary

The Applied Electrostatic Research Centre (AERC) of the University of Western Ontario was awarded by the Department of Supplies and Services Canada, Contract No. 23440-9-9142/01-SZ -Phase II to carry out: **"Feasibility Studies for Coal Dust Control measures at the Quintette Mine, B.C."** .

The AERC team designed and constructed an experimental abatement system for installation in the C3 discharge chute of the Transfer House.

The abatement system consisted of: 12 supersonic ion injection units complete with high voltage power supplies, an optical probe to monitor the coal dust and the mounting frames.

Preliminary experiments were carried out on September 13, 1990, followed by the final experiments on March 4, 1991.

The feasibility studies for abatement of the coal dust generation in the Transfer House at the Quintette mine, indicate that:

1. By supersonic injection of monopolar ions, one may achieve a substantial reduction of the total dust generated.

2. With the experimental apparatus designed for the C3 chute, it is estimated that approximately 30% reduction was achieved.

It is recommended that: to confirm the March 1991 test it will be necessary to plan for additional test during the Winter of 1991/92. If such confirming tests are approved it is planned to either improve the self cleaning of the Optical Probe or use a dust sampler with milipore filters, vacuum pump and controller. A supplementary set of four injection units will be added at the C3 chute.

The equipment which is still in place may be operated by the Quintette personnel. Should some dust conditions develop earlier than next winter, tests could be carried out on a very short notice.

I General

The feasibility studies carried out in Phase II of the project were decided upon at a meeting held at the Quintette Mine on May 17, 1990.

The meeting was attended by: a) several key personnel from Quintette, among them Mr. I.N. Duke, Manager of Processing and Mr. R.C. Stewart, Senior Mechanical Engineer Processing. b) Representatives from the Ministry of Energy, Mines and Petroleum Resources, Mr. David Turner, Inspector of Mines and Mr. Garry A. MacDonald, Inspector of Mines (Mechanical) c) Dr. K.J. Mintz, Research Scientist, Canada Centre for Mineral and Energy Technology, Ottawa, and d) Professor I.I. Inculet, Director of the Applied Electrostatics Research Centre, The University of Western Ontario.

After reviewing the main findings and conclusions of the Phase I[1] of the project which were:

1. The air borne coal dust present in Breaker House, the C_1 and C_1/C_2 Transfer Houses is electrically charged with a positive polarity.

2. The mineral matter in the dust particles is substantially lower than the one in the unwashed raw coal which arrives at the three locations tested. This leads to the assumption that small pieces of clean coal disengage from the coal-clay lumps along layers of embodied mineral matter. The separation of these two materials during breaking or transferring from one conveyor to another results in charges of opposite polarity appearing on both particles, as described by I.I. Inculet, R.M. Quigley and K.B. Filliter[2]. The presence of only positive charges on coal dust substantiates this theory.

3. A possible hazard can be created by a person walking inside a charged dust cloud. If one assumes an imaginary spherical aerosol volume comprising coal dust in the concentrations measured on February 21 and 23, 1990, the electrical potential at the periphery of an 0.9144 metre (3 ft) radius will be 7841 volts.

The dust concentrations during the tests carried out February 21 and 23 were unusually low and, unfortunately, we do not have figures as to the maximum values that could develop at the respective sites. **It is strongly recommended that a new series of test be carried out earlier next winter to determine both the maximum dust concentration and the maximum electric charges.**

Assuming a tenfold increase in the dust concentration, the potential at the periphery of the same spherical volume considered above will reach 78410 volts. Under such conditions, a person wearing electrically insulated boots could accumulate a considerable amount of electrical charge by impaction from the coal dust particles. Depending on the quality of the electrical insulation of the boots, an electrical potential as high as 30kV may be reached by the person. (30kV potential for a human body is a typical value used for ESD - (Electrostatic Discharges) in testing of electronic components.

Given that potential and considering the capacitance of a human body as 150pF, a spark with an energy of 0.135 J could evolve.

4. The size distribution of the collected dust showed a significant difference from the one used by K. Mintz[3]. As it is close to the distribution of the Highvale and Lingan dusts and the explosivity is strongly related to this parameter, it can be expected that the Minimum Explosive Concentration (MEC) lies somewhere between 45mg/1 and 140mg/1. **Even if the measured coal dust concentration were multiplied by a hundred, it would be barely above the MEC and an ignition energy of several hundred Joules would be needed to start an explosion.**

5. If methane develops in any of the houses, even though the energy of the spark cannot ignite the coal dust, it could be sufficient to ignite a possible methane pocket. A methane explosion could create enough energy to generate a secondary coal dust explosion.

it was generally agreed that the Phase II of the project should comprise a feasibility study for abating the coal dust emissions at the critical locations where the dust is generated.

Professor Inculet proposed that the abatement system be based on a relatively new method of supersonic injection of monopolar ions. In this system, the ions may be generated by high voltage corona electrodes mounted inside a steel enclosure continuously purged by clean air, which, at the same time, entrains the ions at supersonic speeds through a small orifice.

The injected ions would charge the coal dust particles and **the electric field produced by the ionic space charge** would repel the charged dust back to the source.

The system was chosen on account of its inherent safety; it prevents any spark discharge from the corona points in the coal dust cloud.

II The Development of the Test Equipment

Prior to designing the supersonic ion injection system to be installed at Quintette Mine, C3 Discharge Chute, a small prototype was built and tested at the Applied Electrostatics Research Centre. Monopolar (+) ions were supersonically injected while uncharged coal dust was continually introduced in a 1 x 0.5 x 0.5 m^3 box and kept airborne by means of a fan. The laboratory experiments were very successful in maintaining a practically dust free environment inside the small box.

Considering that all generated coal dust at the mine is (+)-vely charged, it was expected that the field experiments will give even better results.

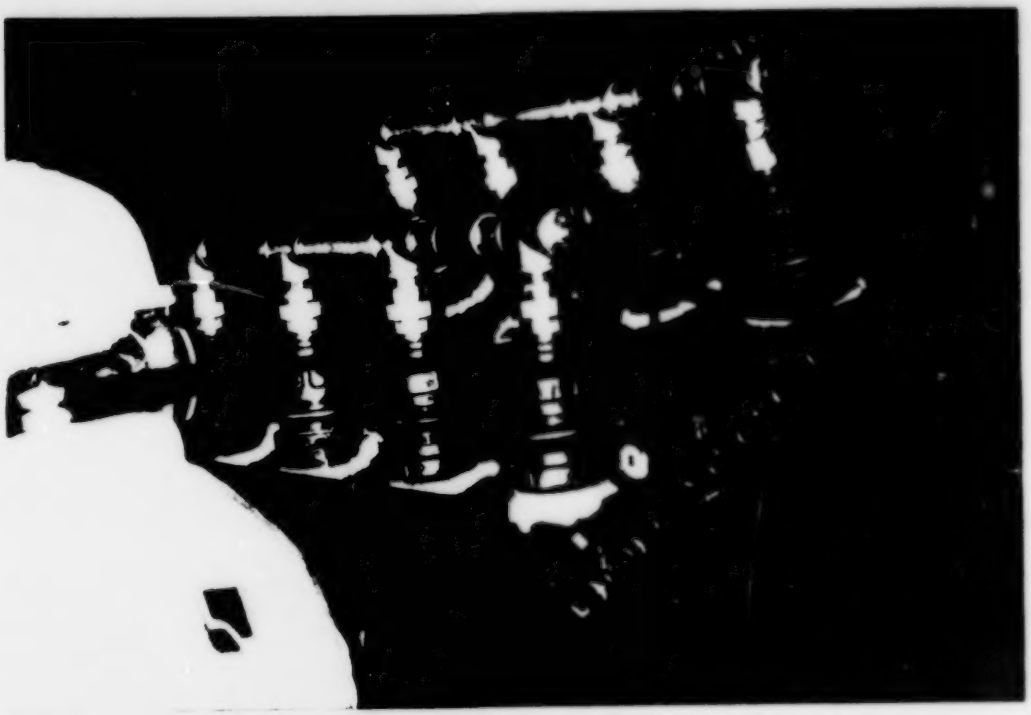
Following the laboratory test, a system was built comprising:

1. 12 supersonic ion injection units.
2. A dust density measuring apparatus [optical probe] to enable the recording of density changes.
3. Mounting frames.

The entire system was designed, built and shipped to the Quintette mine after consultations with and approved by Mr. G.A. MacDonald, Inspector of Mines, Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia.

Photos A1, A2 and B and Figures 1 to 7 inclusive give details of the Test Equipment including the Optical Probe.

A1



A2

Photos A1/A2 view of eight of the supersonic ion injection units being installed on the enclosure of the C_3 Discharge Chute.

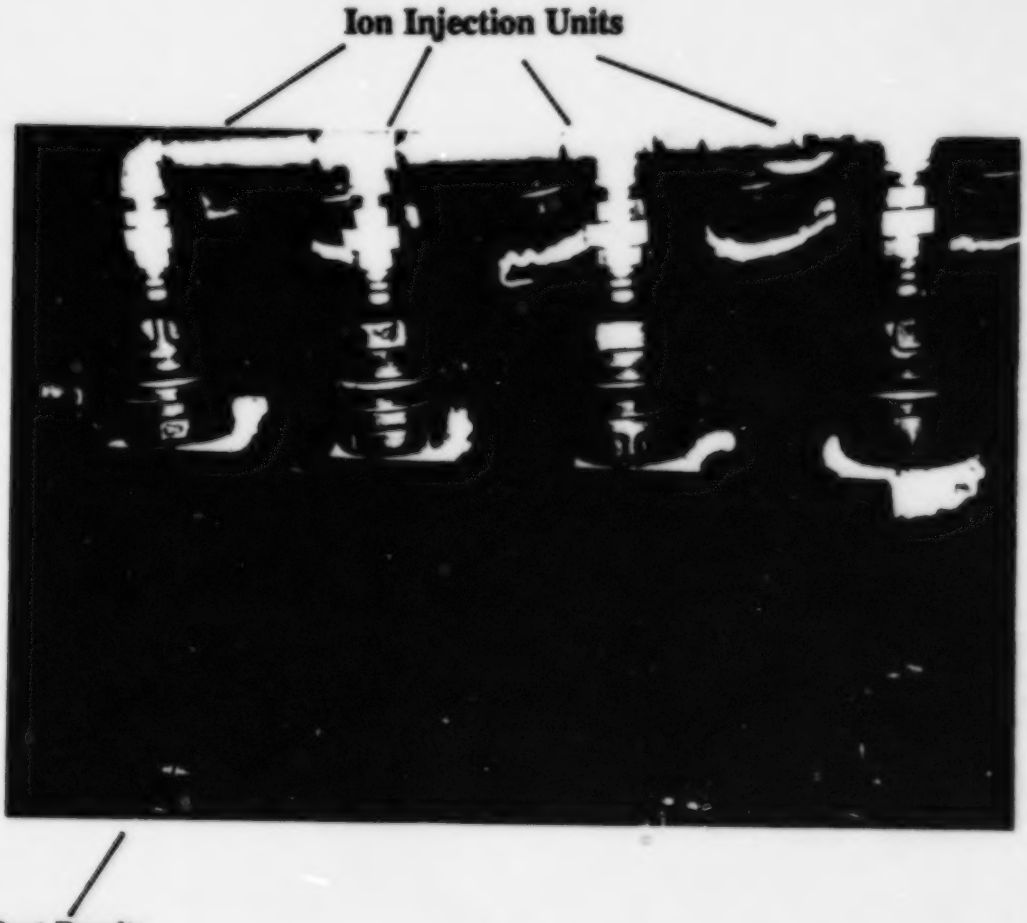


Photo B.

View of some of the supersonic ion injection units installed on the enclosure of the C_3 Discharge Chute. Through the uncovered opening, one sees the dust density apparatus based on the measurement of the intensity of a light beam.

Dust Suppression Experimental Apparatus
for Quintette Mine

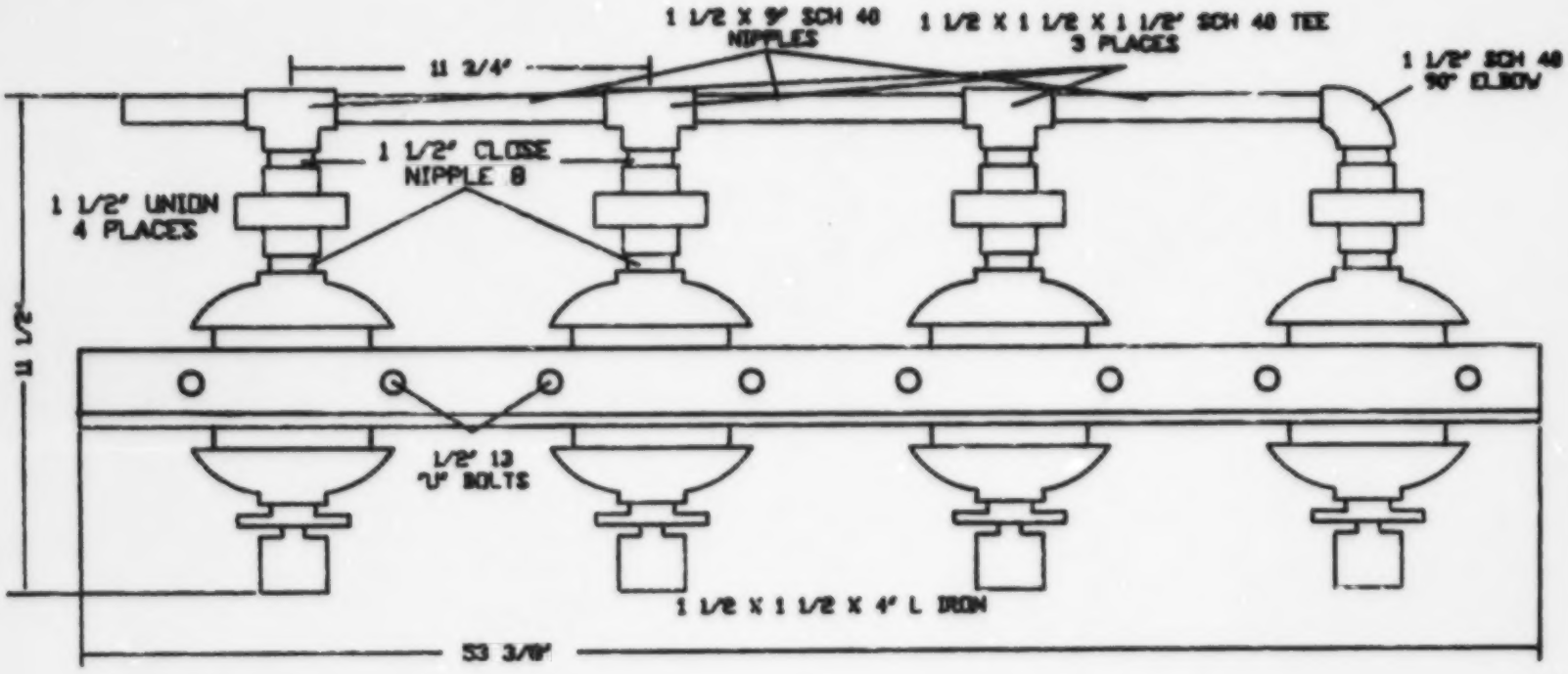

1 1/2 X 9" SCH 40 NIPPLES
1 1/2 X 1 1/2 X 1 1/2" SCH 40 TEE 3 PLACES
1 1/2" SCH 40 90° ELBOW
11 2/4"
1 1/2" CLOSE NIPPLE 8
1 1/2" UNION 4 PLACES
11 1/2"
1/2" 13 "U" BOLTS
1 1/2 X 1 1/2 X 4" L IRON
53 3/8"

FIGURE 1 : One assembled unit; 3 of these units in total.

Dust Suppression Experimental Apparatus for Quintette Mine

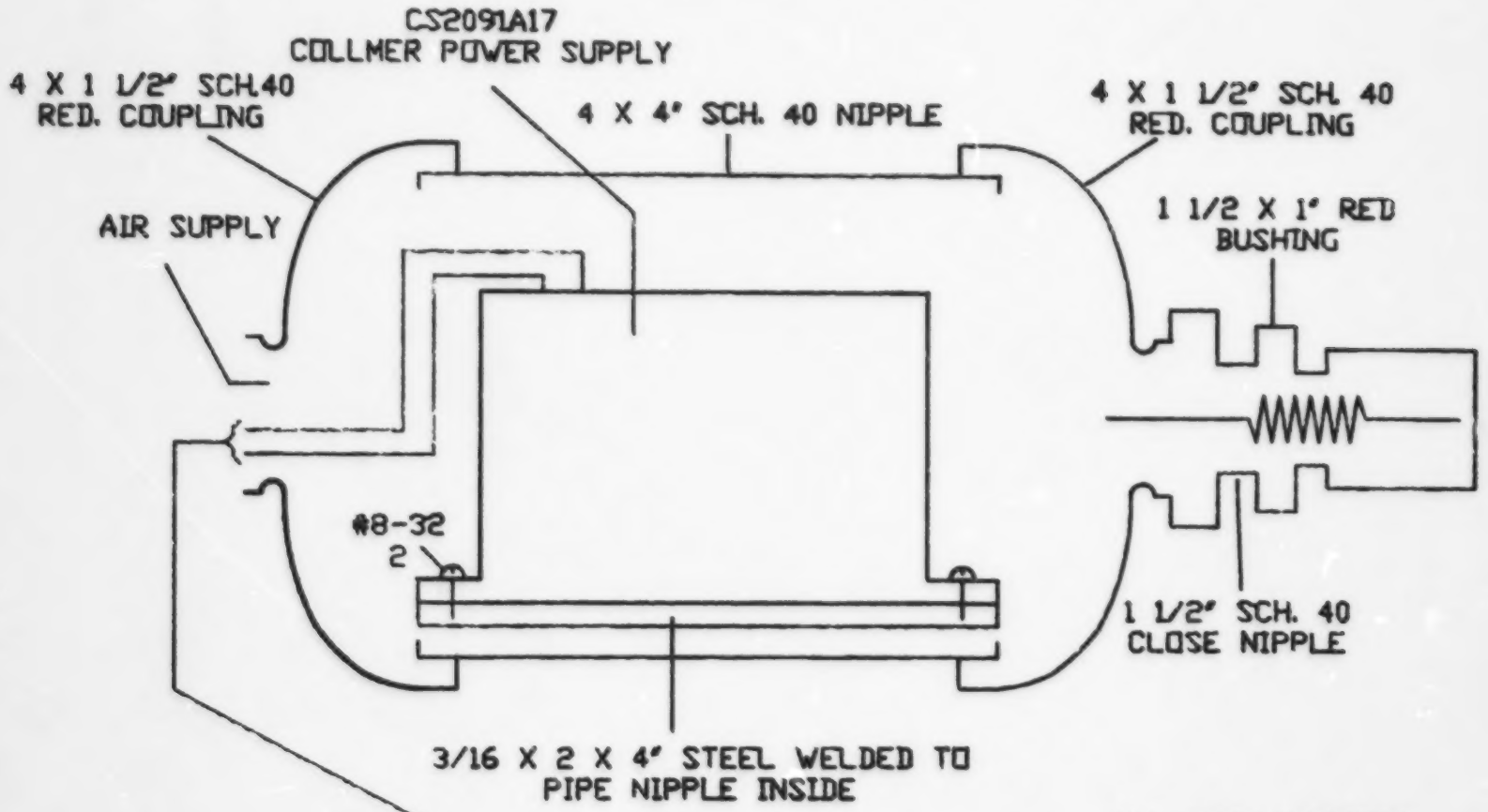
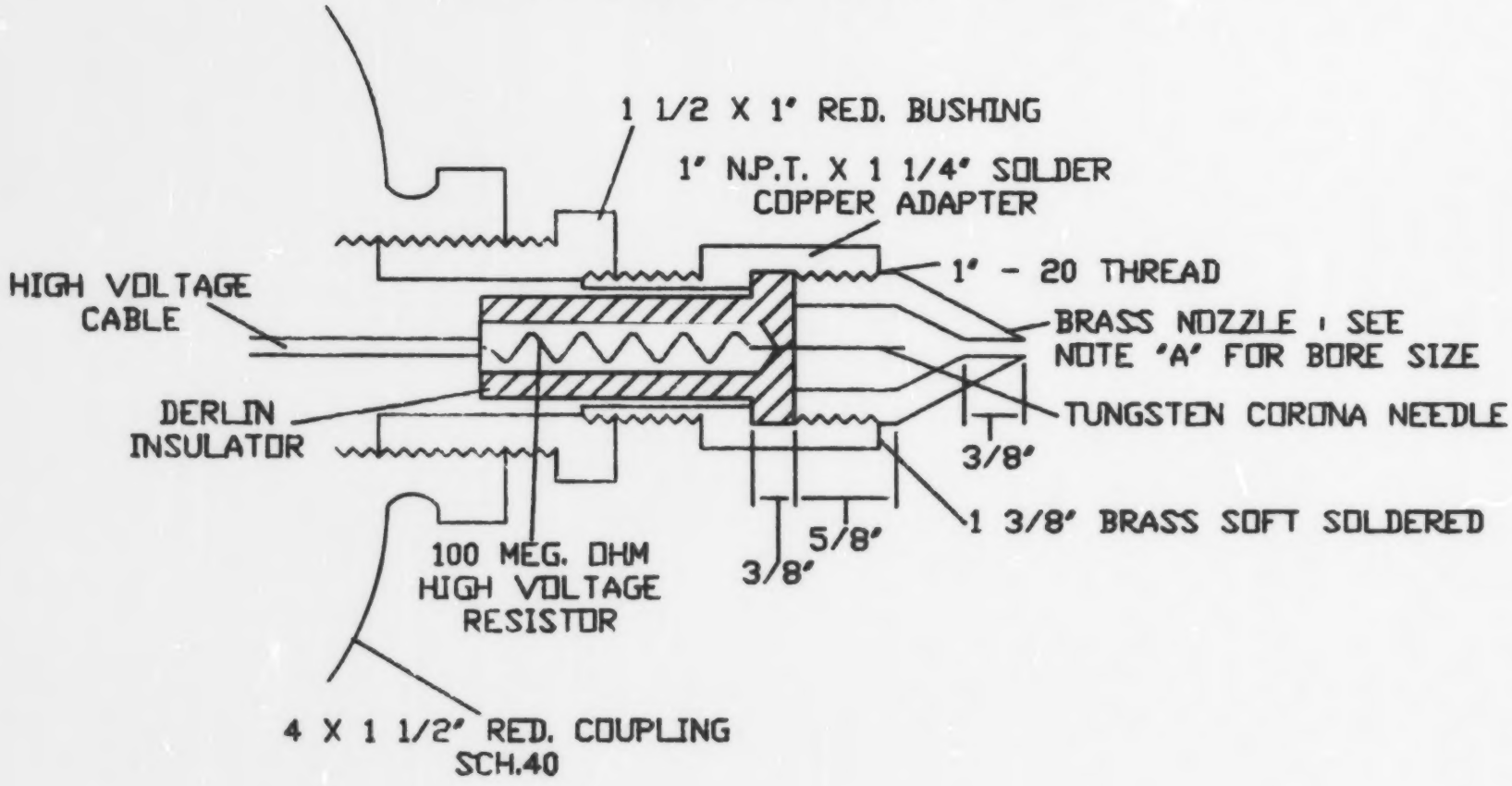


FIGURE 2: Outline of one nozzle.

Dust Suppression Experimental Apparatus for Quintette Mine


1 1/2 X 1" RED. BUSHING
1" N.P.T. X 1 1/4" SOLDER COPPER ADAPTER
1" - 20 THREAD
HIGH VOLTAGE CABLE
BRASS NOZZLE : SEE NOTE "A" FOR BORE SIZE
DERLIN INSULATOR
TUNGSTEN CORONA NEEDLE
3/8"
1 3/8" BRASS SOFT SOLDERED
5/8"
3/8"
100 MEG. OHM HIGH VOLTAGE RESISTOR
4 X 1 1/2" RED. COUPLING SCH.40

NOTE A - BORE SIZE NO. 1 - .080" DIA FOR 20 PSI AIR
BORE SIZE NO. 2 - .250" DIA FOR APPROX. 6 PSI
THESE BORE SIZES ARE TWO ALTERNATIVES.

FIGURE 3: Details of Nozzle Head.

IR LED Light Emitter and Detector

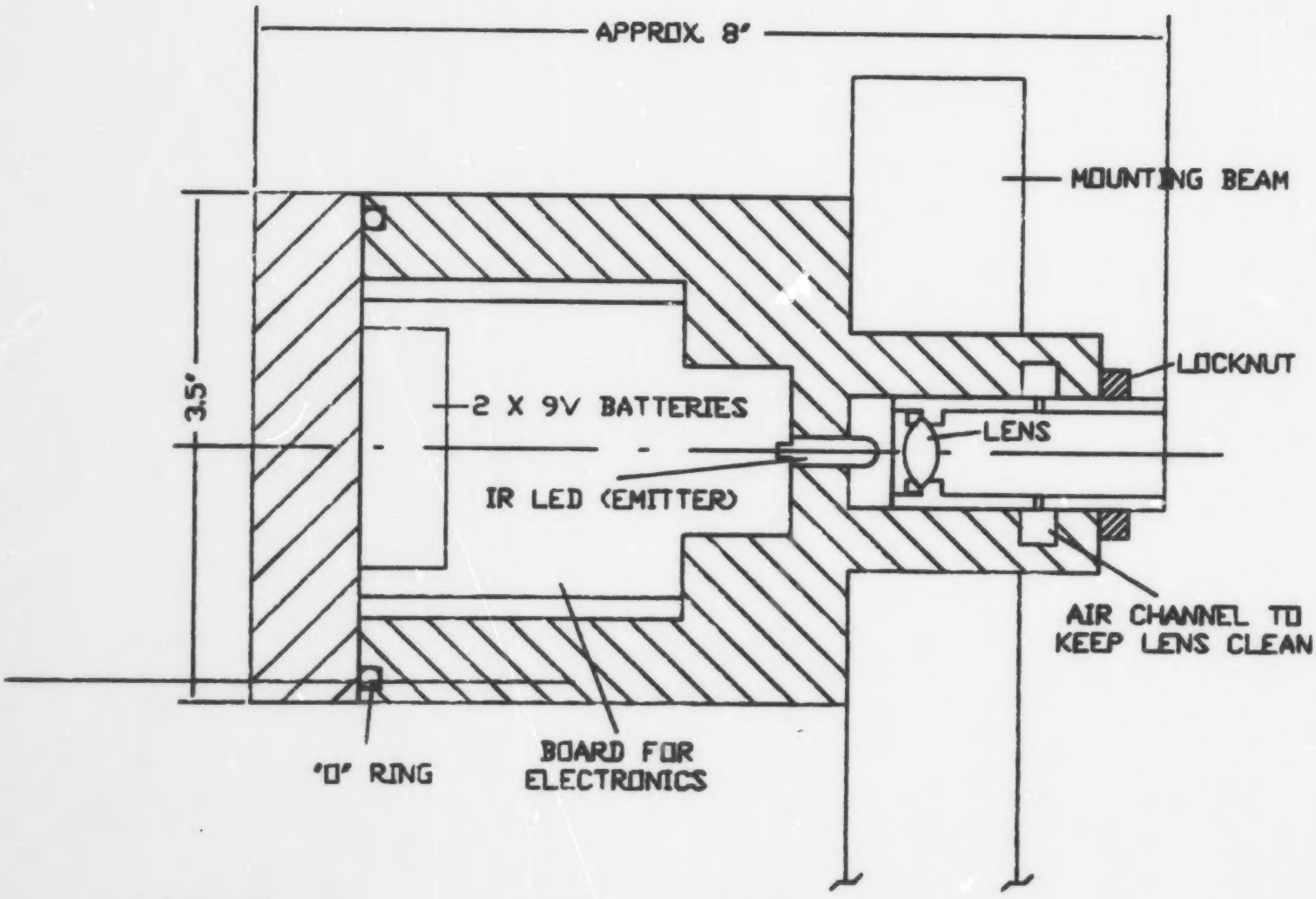


FIGURE 4

MATERIAL : ALUMINUM

Optical Probe With Aluminum Frame

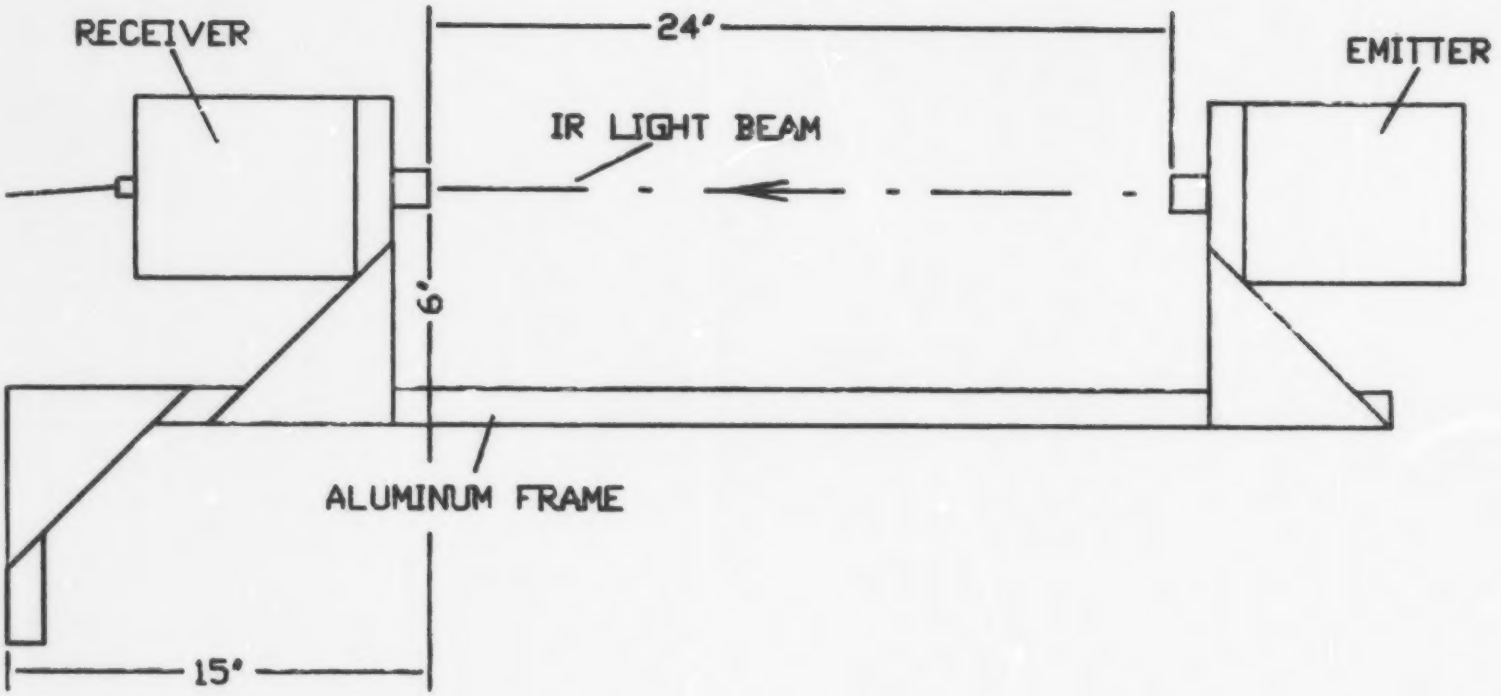


FIGURE 5

Detail of the BNC Connector

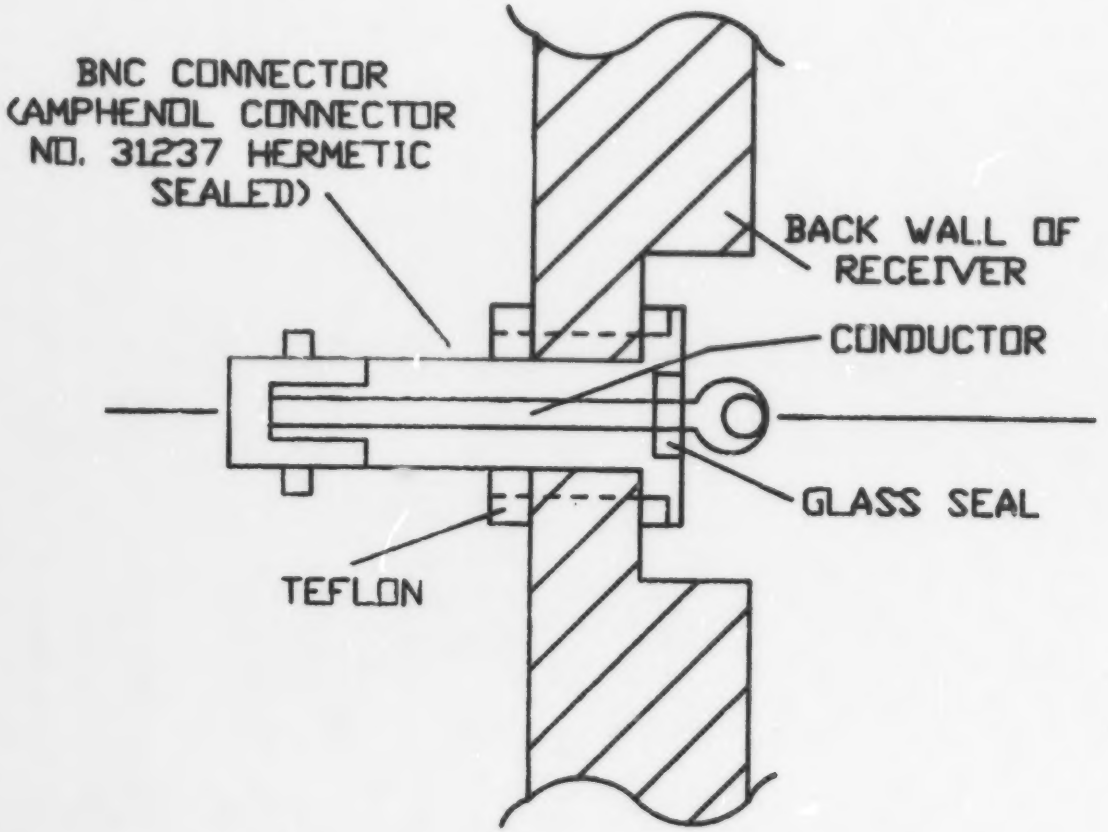


FIGURE 6

Enclosure of the Electronic Circuits Used For the Optical Probe

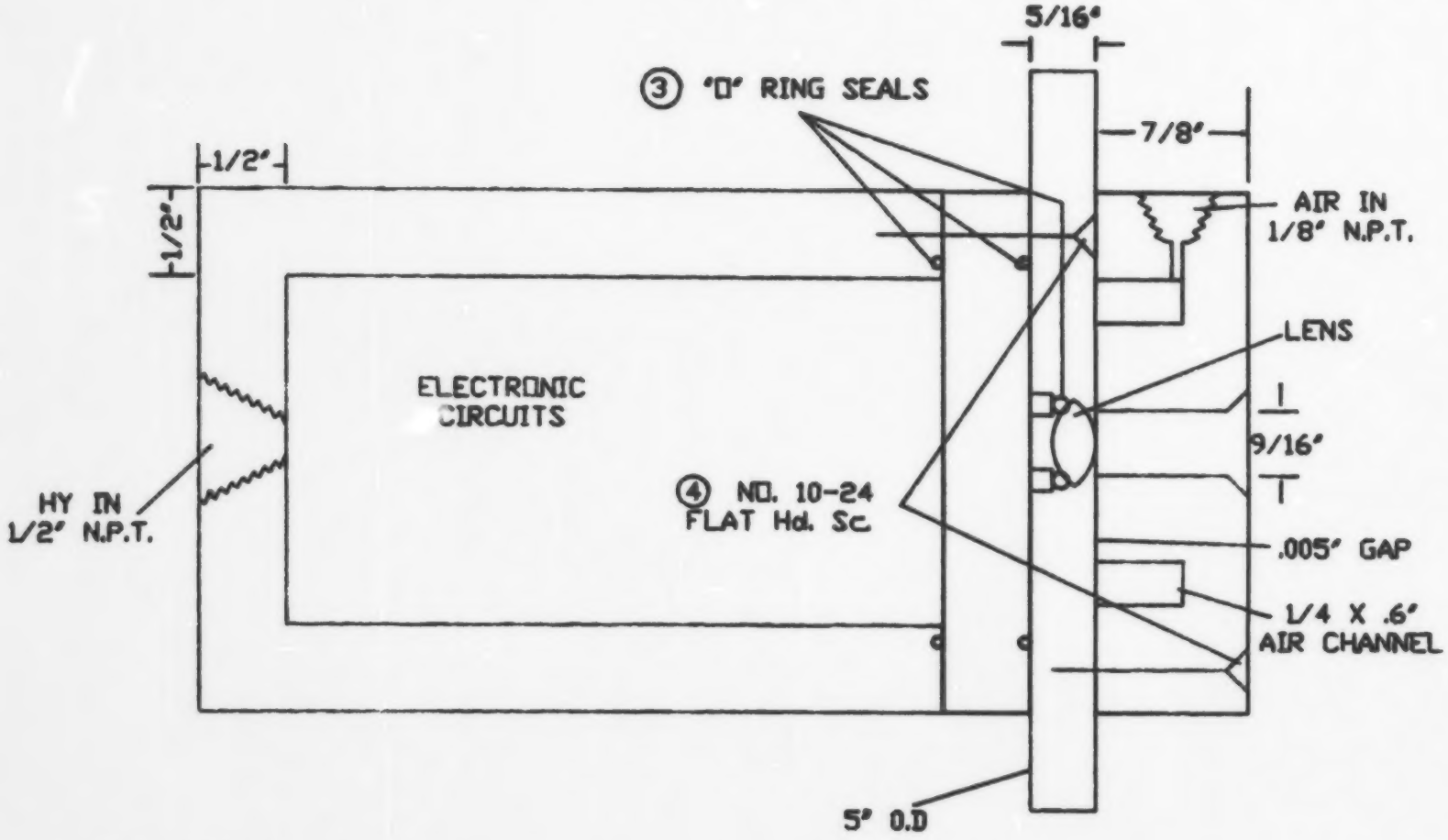


FIGURE 7 ALL MATERIAL BRASS EXCEPT SCREWS.

III Preliminary Tests

After the Experimental equipment was installed at the C3 Discharge Chute some preliminary tests were carried out on September 13, 1990.

Although the early fall conditions are not representative of the very heavy coal dust generation which takes place during some days in winter operations, the September test served to:

1. Check the equipment.
2. Train the Quintette personnel in the use of the equipment to enable them to carry out the winter tests on a short notice.

During the September test, some water in the air which purges the optical probe electronics and maintains the lenses clean, damaged the electronic circuit.

The unit was returned to The University of Western Ontario, where it was repaired and modified to prevent any possible recurrence.

IV. The Full Scale Tests

The full scale tests were carried out on March 4, 1991 by the Quintette Mine Engineering.

The report of Mr. Larry Wolfram of Quintette Coal Limited follows in its entirety.

NOTE: In its attached charts, the higher the light intensity, the higher the recorded value on the vertical axis (UPWARDS).

Quintette Coal Limited

SUBJECT: **CORONA DISCHARGE METHOD OF COAL SUPPRESSION**

TO: Ted Blocka

FROM: Larry Wolfram

DATE: March 12, 1991

In an effort to reduce dusting at conveyor transfer points, the recommended solution of the University of Western Ontario, i.e. Corona Discharge Application, was tested in a field application on the Q.C.L. Overland Conveyor.

Results of the test are attached.

Larry Wolfram

Larry Wolfram

LW/mo

ATTACHMENT

cc: I.N. Duke - Quintette Coal Ltd.
G. MacDonald - Ministry of Mines Energy & Petroleum Resources
Prof. I. Inculet - University of Western Ontario

CORONA DISCHARGE DUST SUPPRESSION

TEST - MARCH 4, 1991

A. WEATHER
- Clear and cold - -13 Deg. C.
- Light Winds
- Humidity not available

B. COAL - Dry and dusty

C. OBJECT - Test Corona Discharge System to see if it is an effective dust suppression system.

D. METHOD
- Twelve Corona Discharge Units were installed in C3 Discharge Chute and connected to air and power.
- Air was left on continuously during test.
- Electrical power was switched on and off to Discharge Units during test.
- The dust intensity in the chute was measured using a light source and a light receiver which produced a variable voltage between 0 and 6 volts D.C. depending upon light intensity. This was recorded on a chart recorder.

E. EXPECTED RESULTS
- If the Corona Discharge works to suppress dust, then a higher level of light should be indicated on the chart recorder at a higher voltage when the system is turned on as to when it is turned off.

F. RESULTS - Refer to Recordings Page 1 to 3

LINE 1 - Start of test - light intensity adjusted in clean air to give approx. 3 volts output.

LINE 2
- Feed turned on.
- Dust level allowed to reach steady state and coronas turned on.
- No significant change on dust level.

LINE 3
- Scale change on chart recorder to increase sensitivity.
- When feed was turned off, corona was turned on.
- When feed returned dust level was allowed to reach steady state and corona was turned off.
- No significant change.

LINE 4 - Two more tests indicate no significant difference between corona on and corona off dust concentrations.

LINE 5 - Feed off most of time.
- One test shows no significant change.

LINE 6 - Dust condition warranted increase in light level to penetrate dust.

LINE 7 - Two tests - one with chute door open and one with chute door closed show no significant change in concentration.

LINE 8 - Feed had been off for approx. 1/2 hour.
- Feed was only lightly dusty when it returned.
- Again tests show no significant difference.

LINE 9 - New feed produced very dusty conditions.
- Corona off test appears better than corona on test.

LINE 10 - Very dusty.
- No significant change in steady state conditions.

LINE 11 - No change to Line 10.

LINE 12 - First and last part of chart show no significant difference.

LINE 13 & 14 Corona was turned on and door closed while feed on. When voltage had dropped to low level, door was opened to reduce dust concentration but light was not touched. Corona was turned off and door was closed.
- Results indicate less dust concentration with corona off than with corona on.

G. CONCLUSION- This test indicated that there were no significant changes to dust concentration whether the Corona Discharge system was turned on or off as no changes to the chart recording were observed during the test.

Consequently, we conclude that the Corona Discharge Method of Coal Dust Suppression under our operating conditions is ineffective, and further testing would be unwarranted.

We will not process further with testing of the Corona Discharge System as test was unsuccessful.

V. Discussion of the Test Results

- As seen from the "conclusion" in the excellent Quintette mine Engineering test record, a first look at the results could make one infer that the supersonic ion injection method was ineffective in abating the dust levels. As such there would be no point in pursuing the project beyond the described feasibility study.

- **However, after a lengthy consideration and detailed review of the test records, the data which comes to light appears to substantiate that the method is a very promising tool for abating the coal dust generation.**

Observations

1. In all tests, the response time of the optical probe appears to be very short, as would be expected. [Seconds or fractions of a second]. This may be seen from the output records during the cleaning of the lens and when some dust was thrown manually into the chute. [see line 13 recorded at Quintette].

   Each time the cleaning of the lens was completed while the feed continued uninterrupted, the optical probe required 2 to 5 minutes to reach a steady level. This was very likely due to a gradual coal dust deposit on the lens.
   Although the air flow was supposed to keep the lens surface clean, it is possible [due to the heavy turbulence present in the chute as well as the charged dust reported in Phase I] for such deposits to be formed.

3. The deposits appear to be sufficiently heavy to prevent any further light intensity charges from being detected.

4. Considering that the steady state light intensity values were dominated by the deposits on the lens, **one must analyze only the measurement taken during the very brief periods when the lenses were clean. i.e.: immediately after the manual cleaning.**

5. In reviewing the light intensity changes [theoretically as a result of coal dust concentrations changes, or deposits on the lens] **immediately after the manual cleaning**, one observes that the light intensity decreases to steady state are substantially larger during the supersonic ion injection as compared to the decreases while the ion injection was off*. e.g.

Line 4 recorded at Quintette.

- with corona "on" the decrease was 1.8 volt
- with corona "off" the decrease was 0.8 - 1.2 volt

Lines 8 and 11 recorded at Quintette

- with corona "on" the decrease was 2.0 volt
- with corona "off" the decrease was 1.2 volt

***NOTE:** One must consider that a decrease in the light intensity while the ion injection is off is very likely due entirely to deposits on the lens.

VI Conclusions

The feasibility studies for abatement of the coal dust generation in the Transfer House at the Quintette mine, indicate that:

1. By supersonic injection of monopolar ions, one may achieve a substantial reduction of the total dust generated.
2. With the experimental apparatus designed for the C3 discharge chute, it is estimated that the approximate 50% increase in light intensity ought to correspond to a 30% decrease in the dust density.

VII Recommendations

To confirm the March 1991 test, it would be necessary to plan for additional tests during the Winter* of 1991/92. If such confirming tests are approved, it is planned to either improve the self cleaning of the optical probe or use a dust sampler with milipore filters, vacuum pump and controllers. A supplementary set of four injection units will be added at the C3 discharge chute.

*Note: The equipment which is still in place may be fully operated by the Quintette personnel. Should some dust conditions develop earlier than next winter, test could be carried out on a very short notice.

VIII References

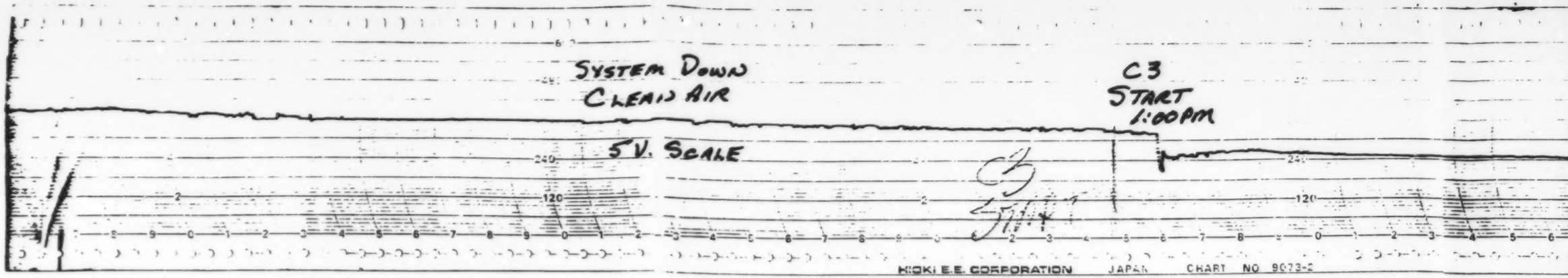
1. Final Report of Phase I of project under DSS Contract No. 23440-9-9142/01-SZ dated May 11, 1990.

2. Ion I. Inculet, Robert M. Quigley and Ken B. Filliter, 1985, "Coal-Clay Triboelectrification", IEEE Transactions on Industry Applications, VOL. IA 21, No.2, March/April 1985.

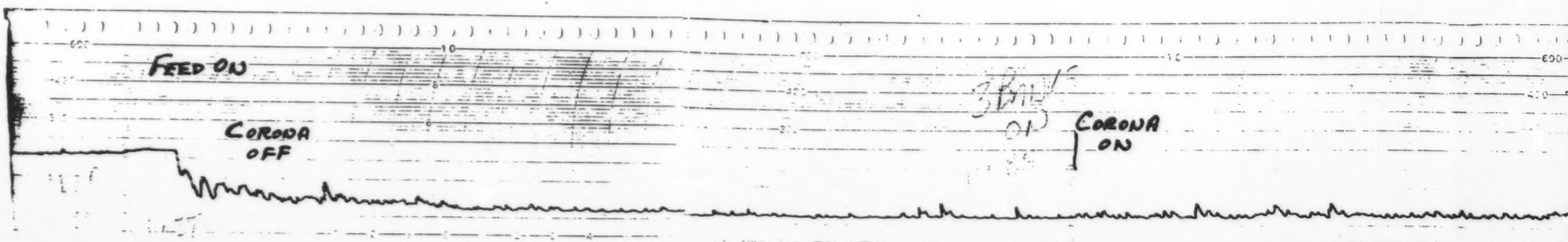
3. K.J. Mintz, "The Explosibility of Three Canadian coal Dusts", Canada Centre for Mineral and Energy Technology, Mining Research Laboratories, MRL 89-50 (TR)(Work Carried out under the PERD program)

PAGE 1

1


SYSTEM DOWN
CLEAN AIR
5V. SCALE
C3
START
1:00PM
HIOKI E.E. CORPORATION JAPAN CHART NO 9073-5

2


FEED ON
CORONA OFF
CORONA ON

3

FEED OFF
OPEN DOOR
CLEAN LENS
CORONA ON

HIOKI E.E. CORPORATION JAPAN CHART NO 9073-2

CORONA OFF

SCALE CHANGE 2V

FEED ON

CORONA OFF

4

CLEAN LENS

CORONA OFF

CORONA ON

CLEAN LENS.

5

FEED OFF

CORONA OFF

LID OPEN

FEED OFF

CORONA ON

LID CLOSED

6

INCREASE LIGHT LEVEL

CHANGE TO 5V SCALE

FEED OFF DOOR OPEN

CORONA OFF

CLEAN

DOOR OPEN

CORONA OFF

NO FEED

FEED OFF

CORONA ON

FEED ON

CORONA IN

LID CLOSED

CORONA OFF

FEED OFF

DOOR OPEN

FEED ON

DOOR OPEN

HIOKI E.E. CORPORATION JAPAN

CLEAR CORONA ON DOOR OPEN

CLEAR CORONA OFF DOOR OPEN

OPEN DOOR

CORONA ON DOOR CLOSED

CORONA OFF DOOR CLOSED

FEED OFF

FEED ON

CORONA OFF

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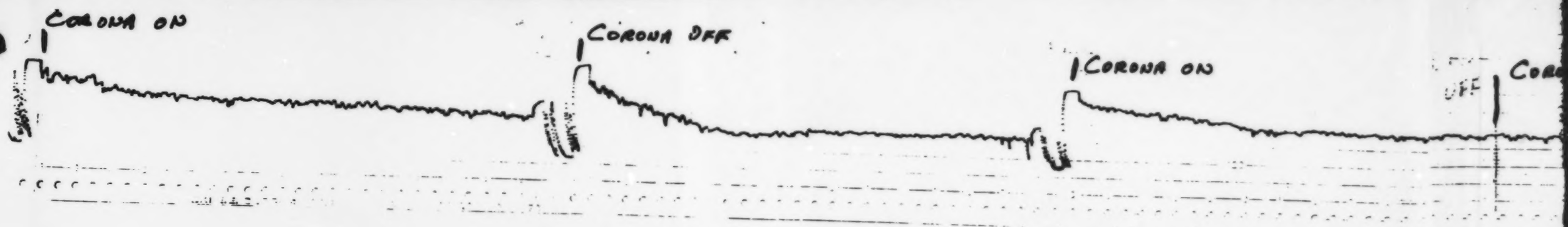
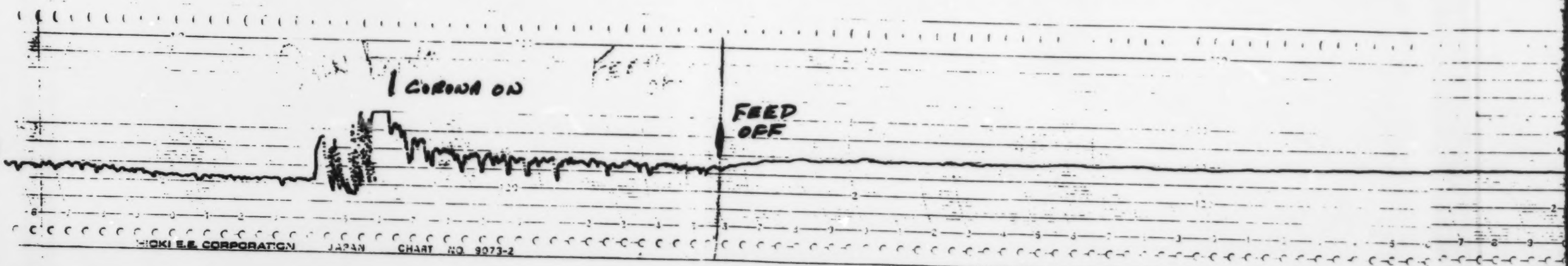
FEED
OFF

CORIDOR OFF

8


CORONA ON
CORONA OFF
CORONA ON

11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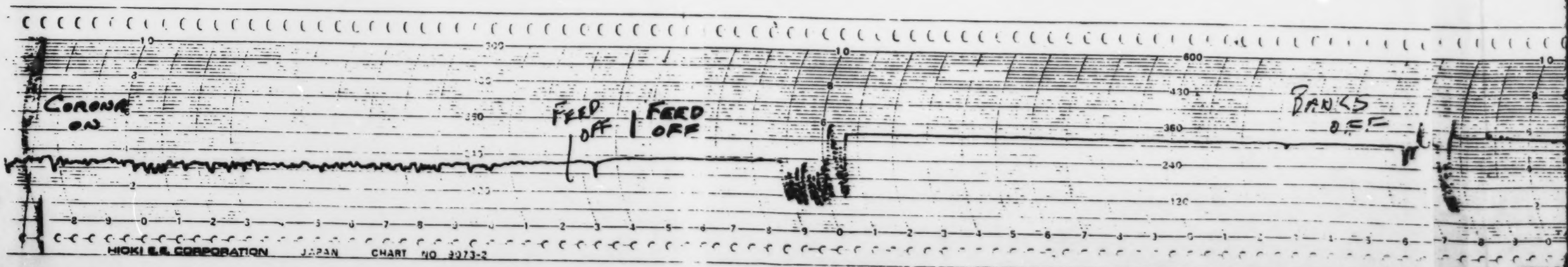
FEED OFF
HIOKI E.E. CORPORATION JAPAN CHART NO 9073-2

12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BANKS OFF
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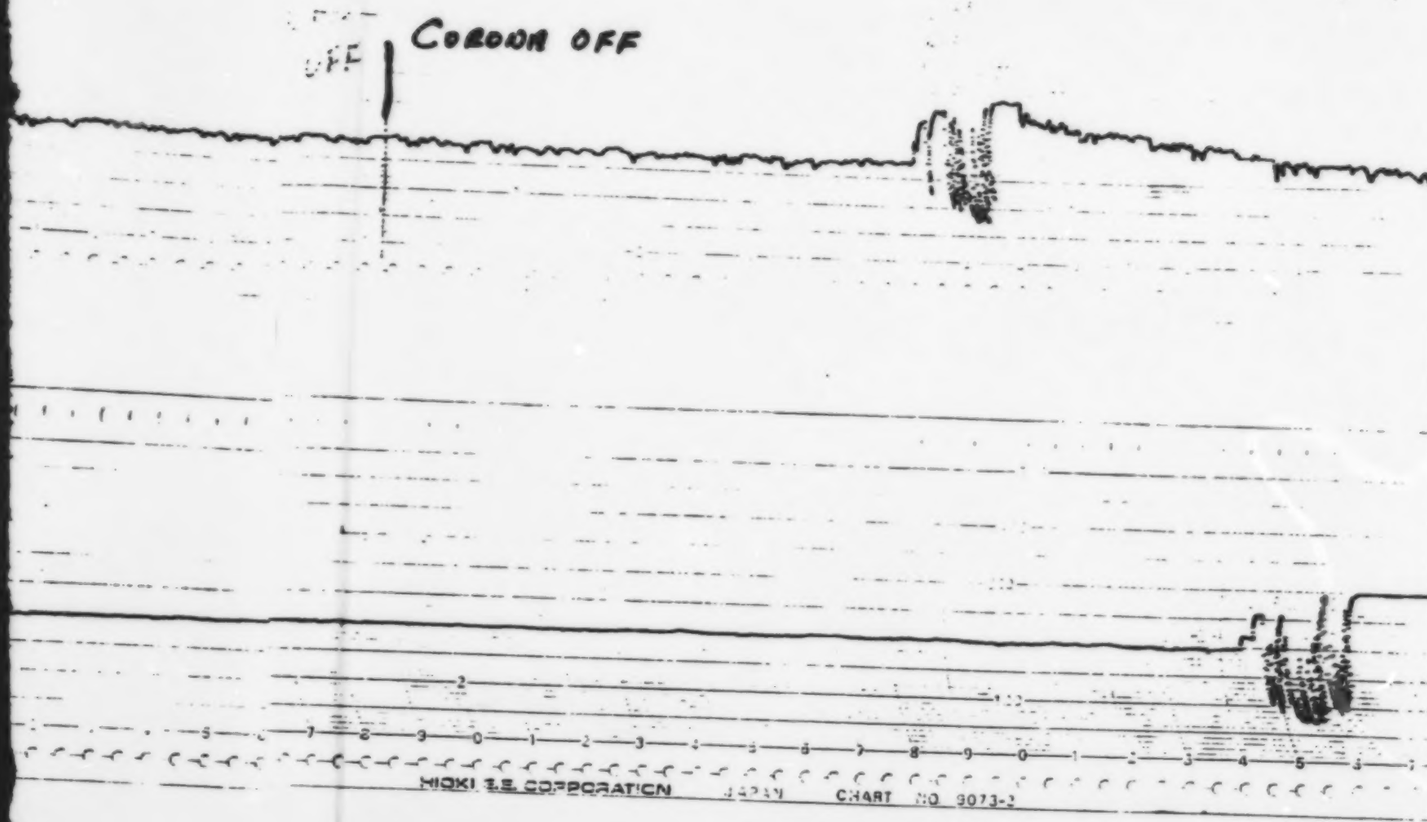
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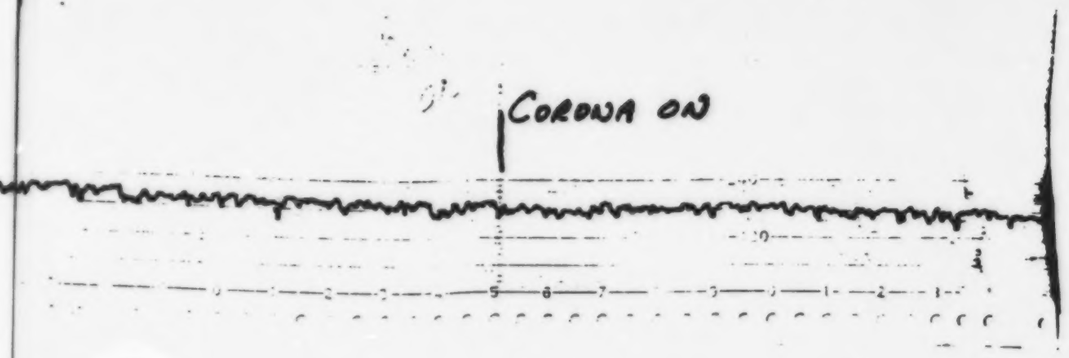
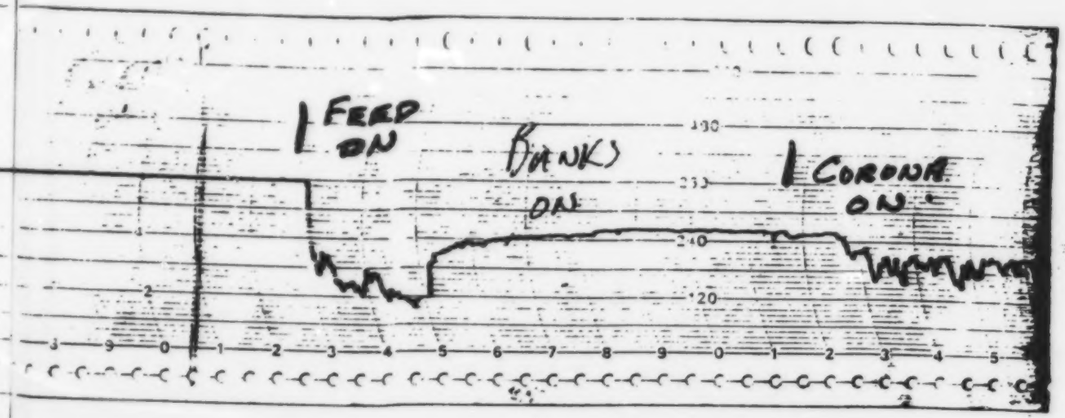
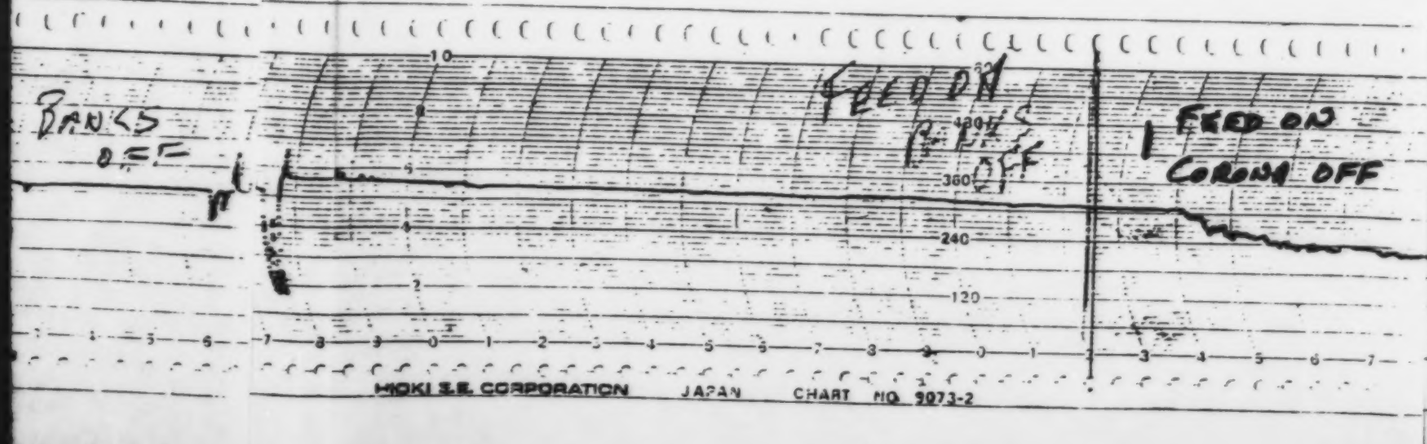
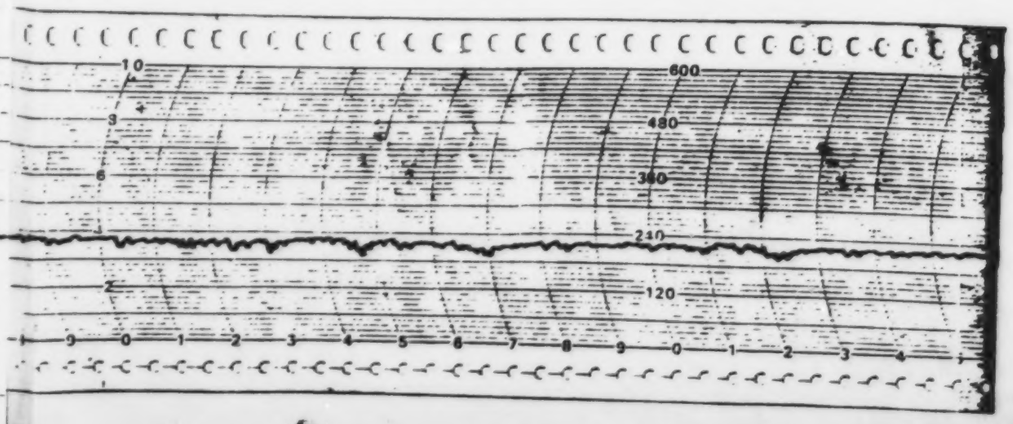
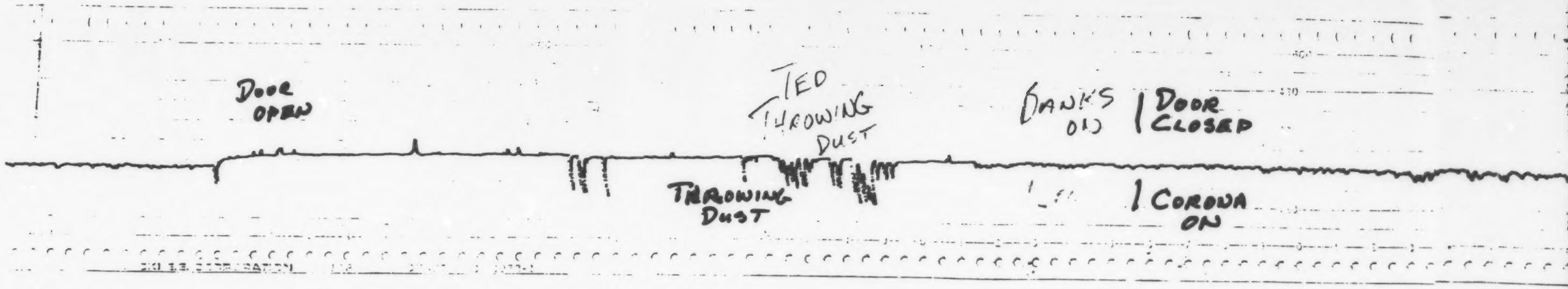

CORONA ON


FEED ON
BANKS ON
CORONA ON

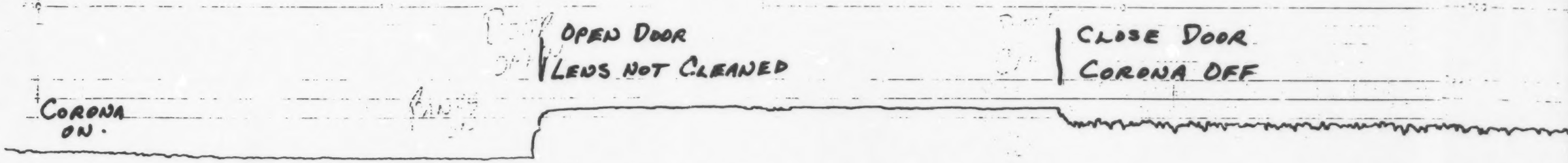

BANKS OFF
FEED ON
FEED OFF
FEED ON
CORONA OFF
HIOKI 3.E. CORPORATION JAPAN CHART NO 9073-2



13

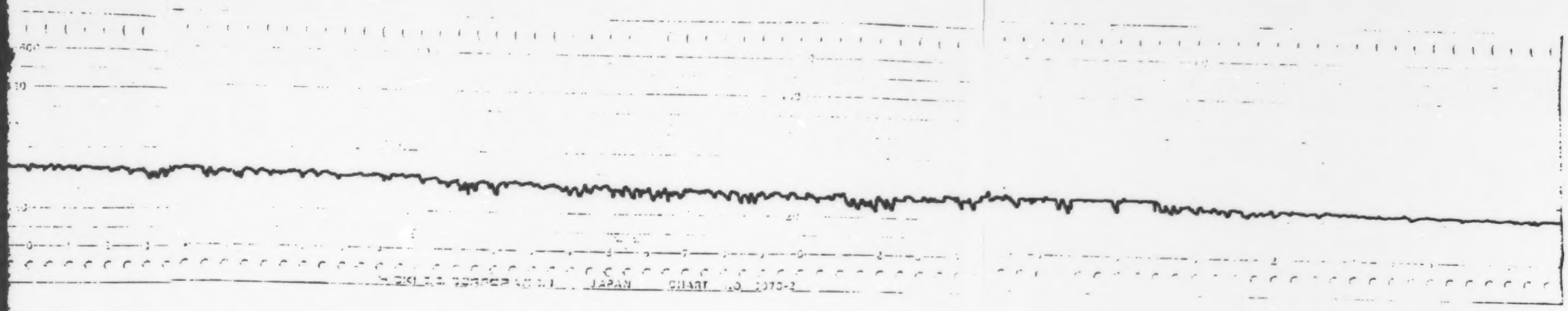


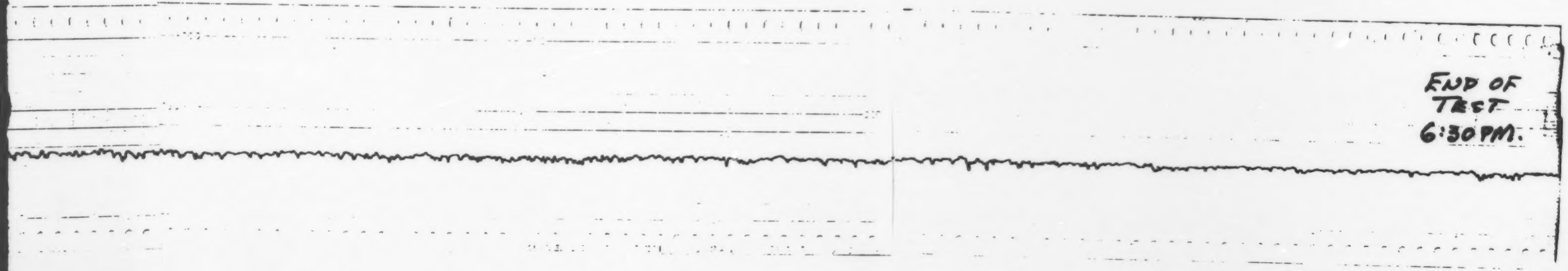
14



NOTE

- TAPES ARE CONTINUOUS EXCEPT FOR TWO SECTIONS OF NO FEED THAT WERE CUT OUT.


JAPAN
CHART NO. 2070-2


END OF
TEST
6:30 PM.